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## **SEVERE WEATHER CLIMATOLOGY FOR NEW MEXICO**

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UNITED STATES  
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## 1. INTRODUCTION

The staff at National Weather Service field offices have no greater duty priorities than to issue timely severe weather warnings for the protection of life and property. A thorough understanding of the state's severe weather climatology can better prepare forecasters for anticipating the timing, strength, extent and nature of severe weather. In addition, a severe weather climatology will provide important information to emergency managers and government or private agencies on the characteristics of severe weather across New Mexico. Therefore, the purpose of this study is to quantitatively describe the severe weather climatology for New Mexico using reports since 1959.

Prior to July 15, 1999 the National Weather Service Forecast Office (WFO) in Albuquerque had the entire state of New Mexico as its forecast area, and roughly the northern two-thirds of the state for its County Warning Area (CWA). The National Weather Service (NWS) Modernization and Associated Restructuring shifted responsibility for seven forecast zones to WFO El Paso, Texas, and shifted three forecast zones to WFO Midland, Texas, on July 15, 1999. This allowed WFO Albuquerque's CWA and forecast area to match (Fig. 1). Although the current WFO Albuquerque forecast area and CWA cover only the northern two-thirds of New Mexico, this study will present climatological data for the entire state.

Unlike nearly all other WFOs in the NWS Southern Region, much of Albuquerque's forecast area is divided into forecast zones, zones not defined by using county boundaries (Fig. 2). This is to better conform to New Mexico's diverse topography. There are 34 forecast zones in New Mexico, 22 of which are in Albuquerque's CWA. New Mexico is the fifth largest state in the United States, comprising nearly 122,000 sq mi. The Albuquerque CWA covers approximately 88,000 sq mi, making it the largest CWA in the coterminous United States. Elevations vary from under 3,000 ft to over 13,000 ft. This elevation range of nearly two miles brings to New Mexico a vast array of climate regimes and some of the most diverse weather in the Southern Region.

Severe weather including tornadoes, large hail and strong winds will be analyzed in this study. In addition, other significant weather events will be examined, including flash floods, lightning, microbursts (wet or dry) and dust devils. While not "severe weather" by strict (NWS) definition, these latter four events are a frequent and often dangerous aspect of New Mexico's weather.

## 2. PRELIMINARY CONSIDERATIONS

### *a. Population Density and Distribution*

According to the 1990 census (The World Almanac and Book of Facts, 1993), New Mexico had 12.5 persons per sq mi. This is extremely low compared to the national average of 70.3 persons per sq mi, and is easily the lowest in the Southern Region. The population density ranges from 359 persons per sq mi in Bernalillo County, where about 40 percent of the state's population lives, to 0.4 persons per sq mi in Catron County. Fourteen of New Mexico's 32 counties have population densities of *less than five persons per sq mi*.

The extremely low population density has likely resulted in many severe weather events not being reported, especially if they occurred away from the highly skewed population centers of the larger

cities in New Mexico. This under-representation of the severe weather data has been addressed by many authors, including Grazulis and Abbey (1983), Doswell (1985), Hales (1993), and Murphy and Vescio (1996). Because the WFO at Albuquerque strongly discourages population-weighted warnings, this study does not discuss the geographical coverage of severe weather in New Mexico. Instead, it focuses on the temporal trends in the severe weather climatology.

#### *b. Communications*

A portion of the lack of communication of severe weather information across New Mexico can be directly related to the low population density. However, the great diversity of people across the state is another factor in the poor communication of weather sensitive data. New Mexico is a land of many different cultures and languages. Native Americans have many tribes with their own governments and languages. There are many Hispanic communities whose residents speak little or no English. New Mexico will remain a multi-cultural society and communication will always create a challenge to the WFO at Albuquerque. Even the most basic communication methods such as the telephone are limited in some communities. The use of the NOAA Weather Radio is scarce as well. A positive influence since November 1996 has been the addition of the amateur (HAM) radio, which has provided more feedback and more reports of severe weather to the forecast staff.

### **3. DATA**

The primary data for this study were obtained from *Storm Data* for the years 1959 through 1998 (NOAA 1959-1998). Compilation of this data set and generation of the statistics was completed using Corel Quatro Pro.

### **4. WEATHER HAZARDS**

#### *a. Thunderstorms...Spring and Summer*

The thunderstorm season in New Mexico is well defined, although it varies considerably between western and eastern sections of the state. The thunderstorm season begins over the High Plains of eastern New Mexico in mid- to late April, peaks in May and June, declines slightly in July and August, then drops sharply in September and October. In contrast, across western New Mexico there are few thunderstorms during the months of April, May and June, but a sharp increase in early July that continues through August, then the frequency of thunderstorms decreases rapidly in September. Over the central mountain chain, thunderstorms are an almost daily occurrence during July and August, especially over the northwest and north-central mountains of New Mexico. In fact, Rasmussen (1971) found the highest thunderstorm frequency in the U.S. for the June through August period was over the Colorado-New Mexico border.

With such a high occurrence of thunderstorms, New Mexico has the unfortunate distinction of having the highest per capita death rate in the Nation from lightning. In Table 1 the number of lightning deaths per million people by state is shown for the ten states with the highest death rate. This table was computed using 40 years of *Storm Data* statistics.

**Table 1.** Lightning Deaths Per Million People (1959-1999).

Rank	State	Deaths per Million People
1.	New Mexico	72.5
2.	Wyoming	60.0
3.	Arkansas	55.5
4.	Florida	45.4
5.	Colorado	44.1
6.	Georgia	42.0
7.	Mississippi	39.2
8.	Texas	35.2
9.	Oklahoma	34.3
10.	Louisiana	32.9

Thunderstorms also have different characteristics within the state. Across the Eastern Plains thunderstorms often develop in a significantly sheared environment, either along a dryline or with a low-level moist inflow from the southeast, beneath a west or northwest flow in the mid- and high troposphere. These thunderstorms tend to be more organized, long-lived and occasionally severe, producing large hail, high winds and tornadoes. Thunderstorms in the west tend to be less severe on average, however, they do occasionally produce life-threatening flash floods and are noted for their prolific small hail accumulations. Most of the storms in western New Mexico are associated with the “Southwest Monsoon,” especially over the southwest counties. Large hail and tornadoes over the west are rare, with the main threat being flash floods. After updating flood statistics described by Dittman (1994), the state ranks ninth in the nation in per capita deaths from flash floods. Table 2 shows the number of flash flood deaths per million people for the ten states with the highest death rates, as determined from *Storm Data* statistics.

**Table 2.** Flash Flood Deaths Per Million People (1959-1999).

Rank	State	Deaths per Million People
1.	South Dakota	149.3
2.	West Virginia	139.7
3.	Texas	127.3
4.	Colorado	70.9
5.	Montana	66.2
6.	Georgia	54.6
7.	Vermont (tie)	50.0
7.	Virginia (tie)	50.0
9.	New Mexico	49.2
10.	Arizona	48.9

### *b. Winter Weather...Fall Through Spring*

Winter storms are a frequent occurrence across New Mexico from October into May. Snowfall within the state ranges from an average of under five inches per year at the lowest elevations of the Rio Grande Valley to between 200 and 300 inches in the higher elevations of the Sangre de Cristo Mountains. Sleet and freezing rain are rare, but they do occur, primarily on the Eastern Plains. Winter storms rank third in causing the most fatalities and injuries across the state each year on average. Only lightning and floods/flash floods result in more fatalities per year, and only lightning causes more injuries (Figs. 3 and 4). Spring is often the busiest time of the year at the WFO in Albuquerque. It is not unusual to have winter storm warnings, severe thunderstorm and tornado warnings, and high wind warnings in effect at the same time!

## **5. SEVERE WEATHER CLIMATOLOGY**

By definition, a severe thunderstorm produces a tornado, winds of at least 50 kt (58 mph), and/or hail at least 0.75 diameter (WSOM Chapter C-40). These three types of severe weather will be the primary focus of this study. As mentioned previously, this study will also briefly discuss other significant weather events in New Mexico, including flash floods, lightning, dry or wet microbursts, and dust devils. Fig. 5 lists the total number of all of these events by year. The noticeable increase in severe weather events since 1987 can be partially explained by the increase in population, measured public awareness and better storm spotter education and organization. It will be shown later that while the number of reported tornadoes exhibited little change from 1959 to 1998, there was a significant increase in the number of reported hail and flash flood events.

### *a. Tornadoes*

Tornadoes are a common occurrence in New Mexico, primarily across the Eastern Plains. Fig. 6 shows the distribution of reported tornadoes by county since 1950, based on a 10,000 sq mi area. A distribution based on an area, rather than strictly by county, was used in order to show a more smoothed representation of the number of tornadoes over a given area. These statistics reveal that eastern New Mexico is the western extension of “tornado alley.” Fig. 7 displays the number of reported tornadoes by year. Although the number varies widely from year-to-year, the average is about ten reported tornadoes per year. Despite the rather high frequency of tornadoes, only two fatalities have been reported since 1959, while 115 injuries were documented. The low number of fatalities can be partially explained by the strength of tornadoes found across the state. Since the mid-1980s, tornado strength has been measured using the Fujita Scale, or F-scale (Fujita 1981). This scale ranks tornadoes by damage intensity, with F0 being the weakest and F5 being the strongest. It is important to note the damage intensity was developed by relating wind speed ranges to various degrees of structural damage. With an obvious lack of structures in New Mexico, the application of the Fujita Scale is difficult. In Fig. 8, the reported New Mexico tornadoes are listed by F-scales. While the strength of many tornadoes is not known, less than 5% of the tornadoes with a known intensity are in the strong category (F2 or F3). For the period 1880-1989, Grazulis (1993) notes only four F3 tornadoes in New Mexico. Based on this information and *Storm Data*, it is clear that a high percentage of reported tornadoes in this state are weak, either F0 or F1.

Fig. 9 depicts the monthly frequency of all reported tornadoes. Over 95% of tornadic storms occur in April through September, with about 60% occurring in May and June. Tornadoes have been

reported in all months except January, February and November, while F2 tornadoes were only recorded in May, June and July. Fig. 10 shows the frequency of tornadoes by hour, indicating a majority of tornadic storms occur between 2:00 PM and 7:00 PM MST. The number of tornadoes occurring after dark (8:00 PM MST) is very small, with no reports of tornadoes between 2:00 AM and 7:00 AM MST. This is likely another factor helping to keep the number of tornado fatalities and injuries low across New Mexico, since in other areas the threat of death or injury from nighttime tornadoes is significant.

### *b. Hail*

Hail ranks as the most frequent type of severe weather in New Mexico, and it is responsible for a considerable percentage of property and crop damage. However, only one fatality and 20 injuries have been reported due to hail. Fig. 11 illustrates the number of hail events per year. As noted earlier, the significant increase since 1987 is likely due to an increase in population and land use, and an increase in public awareness of severe weather through more aggressive spotter training at the WFO in Albuquerque.

Fig. 12 shows the number of hail reports by month and by size. Damaging or severe hail (0.75 to 2.00 in) is most common in May and June, as is very large hail (over 2.00 in), although a significant number of hail reports also occur in July through September. The size of some reported hail is not known, but the reports were included in *Storm Data* because they caused significant crop and/or property damage, or had a significant accumulated depth. Those reports are included in this study due to their likelihood of meeting the size criterion for severe hail. Fig. 13 reveals damaging hail is most likely to fall in the afternoon and early evening, as is the case with tornadoes. Nearly 70% of the reported large hail events occurred between 2:00 PM and 6:00 PM MST.

### *c. Wind*

It is difficult to determine from *Storm Data* reports whether a high wind event was the result of a severe thunderstorm, microburst, or larger scale weather system, therefore, this study included any wind event which caused injury or fatalities. There have been four fatalities and over 100 injuries due to high winds. Fig. 14 shows the monthly frequency of all wind events. A pronounced summer maximum is evident, undoubtedly associated with thunderstorms. The spring and fall months contain wind damage from dry microbursts, when low-level moisture is often lacking. March through May also have a large number of events that are related to springtime winds, when relatively strong jet stream winds mix down to the surface. There is a significant number of wind events in the winter months of December through February as well, associated with large scale weather systems.

## **6. SIGNIFICANT WEATHER EVENTS**

### *a. Flash Floods*

Flash floods are responsible for more fatalities than any other weather event across the nation. In New Mexico, flash floods rank second to lightning in the number of reported fatalities (Fig. 3). The yearly distribution of flash floods is shown in Fig. 15, and as with the reported number of hail events, there has been a significant increase in reported flash floods since 1987. The monthly distribution

of flash floods is shown in Fig. 16, illustrating a strong association with the summertime “Southwest Monsoon,” with nearly two-thirds of the flash floods occurring in July and August. Unlike much of the western U.S., there is no significant secondary maximum in the winter months. Fig. 17 shows the distribution of flash floods by hour. Most of the flash floods occur between 3:00 PM and 7:00 PM, similar to the peak hours of severe hail and tornadoes.

#### *b. Lightning*

Thunderstorms and lightning are a common occurrence in New Mexico, especially during the summer months. Because the state has one of the highest thunderstorm frequencies in the nation, New Mexico has the highest lightning fatalities per capita in the U.S. Fig. 18 depicts the monthly distribution of significant lightning events. We define “significant” lightning as causing death, injury or property damage such that the event is reported in *Storm Data*. The majority of lightning events occur in May through September, with a peak in July and August. This is slightly different from that of tornadoes and hail. The maximum infrequency of lightning events corresponds to the “Southwest Monsoon” of July and August.

The hourly distribution of lightning is shown in Fig. 19 and is similar to that of tornadoes and hail, except there is a pronounced early peak around noon MST. This early maximum is the result of the initial formation of thunderstorms over the mountains, particularly the northern mountains, and is supported by Fosdick and Watson (1985). The latter peak is the result of more widespread thunderstorm development during the afternoon and early evening hours.

#### *c. Wind Events*

As with much of the nation, New Mexico has its fair share of wet microbursts which produce damaging convective winds. They are most common during the heart of the summer, in July and August. The *dry* microburst is more unique and found mainly in the southwest U.S. and on the High Plains, just east of the Rocky Mountains. Conditions favorable for dry microbursts include a subtropical jet providing sufficient moisture to the mid and upper levels of the troposphere, with a deep, dry adiabatic layer in the low levels. These conditions are found most often across New Mexico in the transition periods into and out of summer. Only a very small sample of known microburst damage presented in *Storm Data* and no real microburst climatology exists. However, it is accepted by the staff at the WFO in Albuquerque that damaging winds from dry microbursts are a common occurrence in New Mexico and pose a danger to people and property.

Another fairly common wind event in this state is the dust devil. While most dust devils are harmless, overall they do cause several thousands of dollars of damage in New Mexico nearly every year. For that reason we consider them in the category of significant wind events. Sinclair (1973) provides a thorough description of this aspect of dust devils. The WFO Albuquerque staff has noted dust devils are strongest and occur with greater frequency on days with the greatest microburst potential. It is possible a few deaths attributed to tornadoes may actually have been caused by strong dust devils. In 1992, for example, a dust devil produced a 70 mph wind (measured) at the Albuquerque forecast office, equivalent to what could be expected in a typical severe thunderstorm.



## 7. SUMMARY

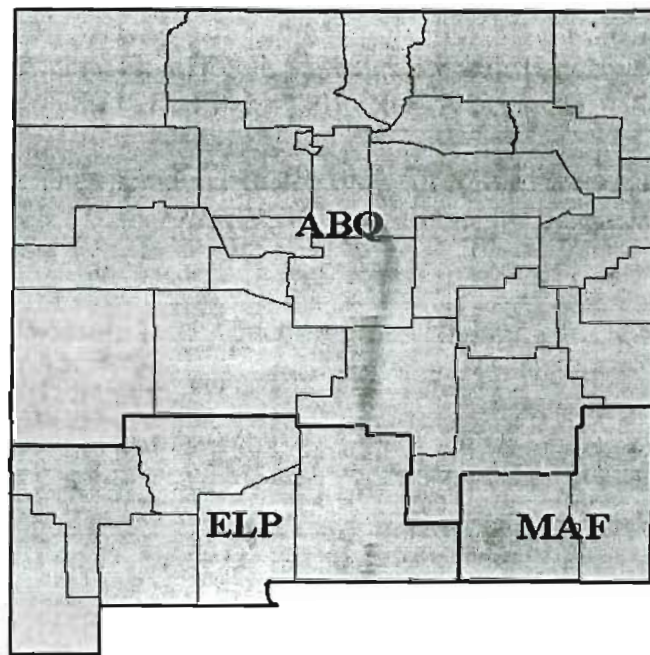
The results of this study can be summarized as follows:

- ◆ WFO Albuquerque's CWA is the largest and has the most diverse topography in the Southern Region, with approximately 88,000 sq mi and topography varying over a range of nearly two miles.
- ◆ New Mexico's population density averages only 12.5 persons per sq mi, easily the lowest in the Southern Region. By comparison, the national average is 70.3 persons per sq mi.
- ◆ The great diversity of cultures among New Mexico citizens, and the lack of communication and equipment across the state, have contributed to occasional difficulties in relaying severe weather information.
- ◆ The highest thunderstorm frequency in the U.S. during the summer (June through August) occurs over the northern mountains, near the New Mexico/Colorado border.
- ◆ Tornadoes and severe hail peak in May and June, while high wind events peak in June and July.
- ◆ Most of the tornadoes and severe hail occur between 2:00 PM and 7:00 PM MST.
- ◆ Most tornadoes in New Mexico are weak, either F0 or F1. There have been no reports of tornadoes stronger than F2.
- ◆ Flash floods peak during the "Southwest Monsoon" season of July and August. New Mexico ranks ninth nationally in flash flood fatalities per capita.
- ◆ Lightning is responsible for more fatalities and injuries than any other weather event in the state. New Mexico has the highest lightning fatalities per capita in the U.S.
- ◆ Little information is available concerning microbursts and dust devils, but they are a frequent and potentially dangerous event during the spring through early fall months.

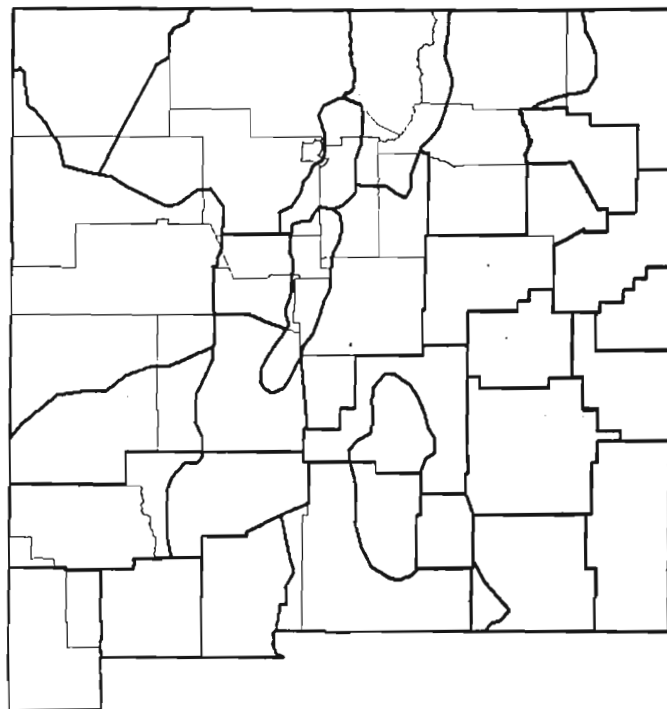
*Acknowledgments.* The author would like to thank Deirdre Kann, SOO at WFO Albuquerque, for her critique of this report and generating much of the severe weather data used in this study. Also, special thanks to Katy Galway for preparing the graphics used in this study. The spreadsheet containing the *Storm Data* events was compiled by Melissa Ficek and Jennifer Palucki.

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**Figure 1.** New Mexico's county warning and forecast responsibility areas for the office in Albuquerque (ABQ), El Paso (ELP) and Midland (MAF).



**Figure 2.** New Mexico's forecast zones (thick black lines). County boundaries are thin gray lines.

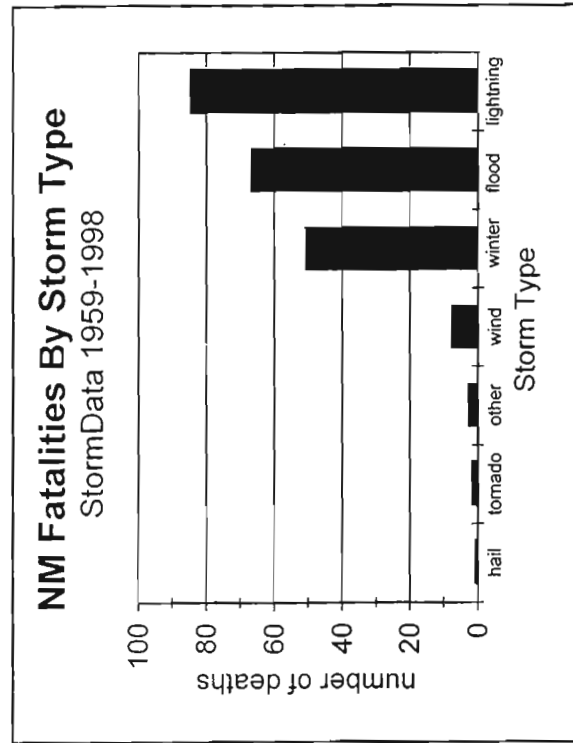


Figure 3. Total number of fatalities from all storm types.

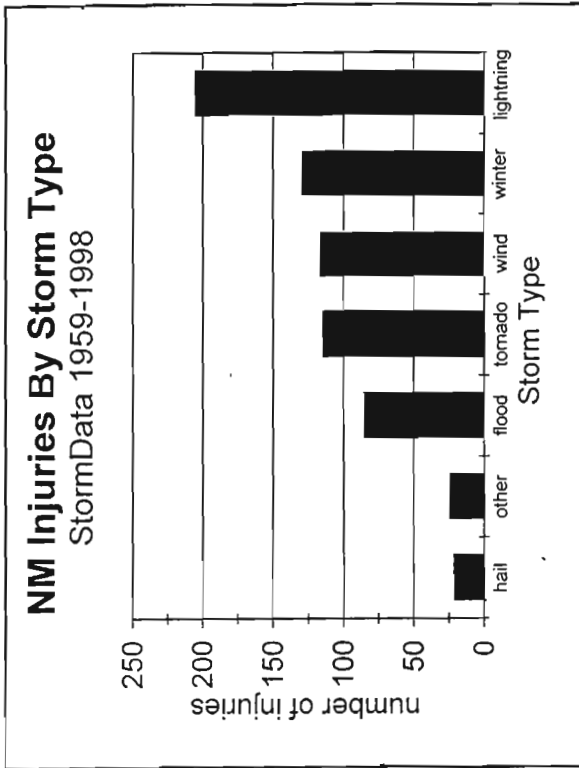


Figure 4. Total number of injuries from all storm types.

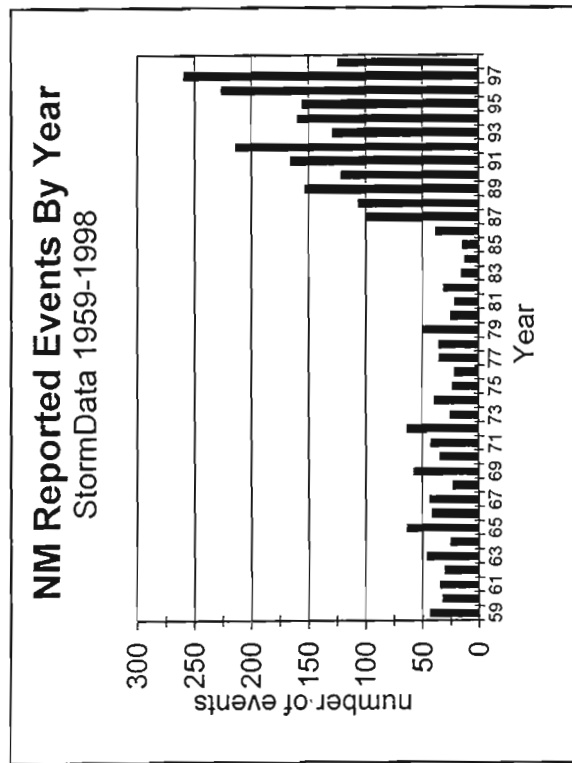


Figure 5. Yearly frequency of all severe and significant weather events reported in StormData.

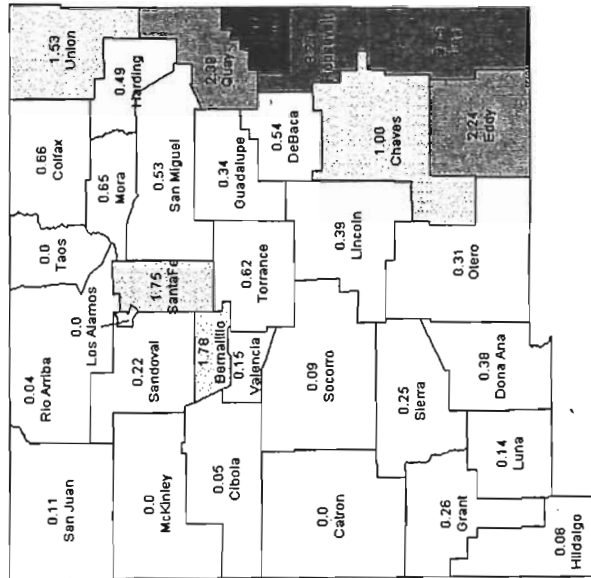
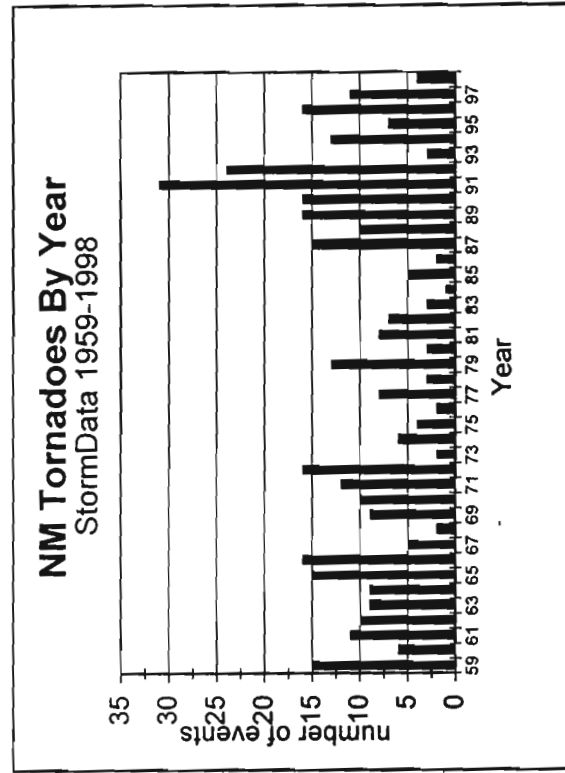
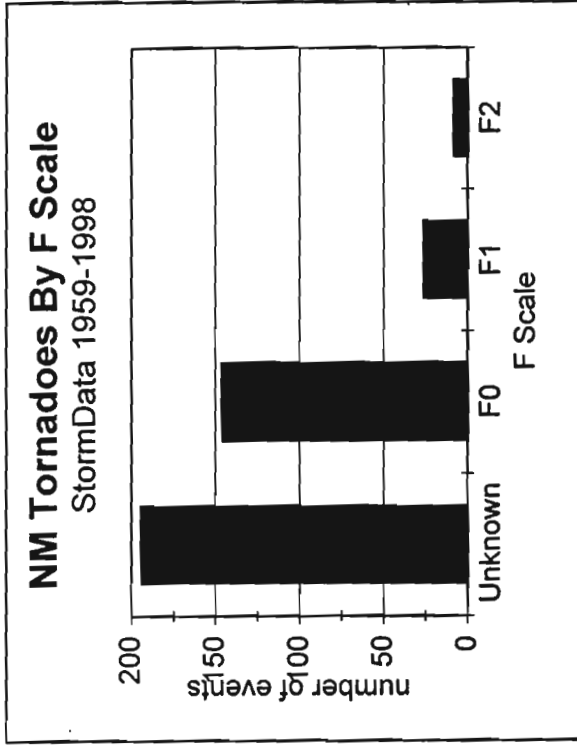


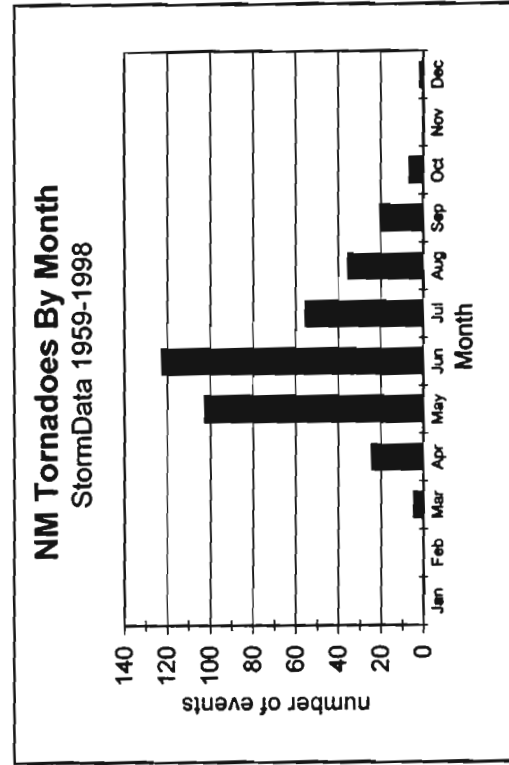
Figure 6. Distribution of reported Tornadoes by county since 1950. Based on a 10,000 sq. mi. area.



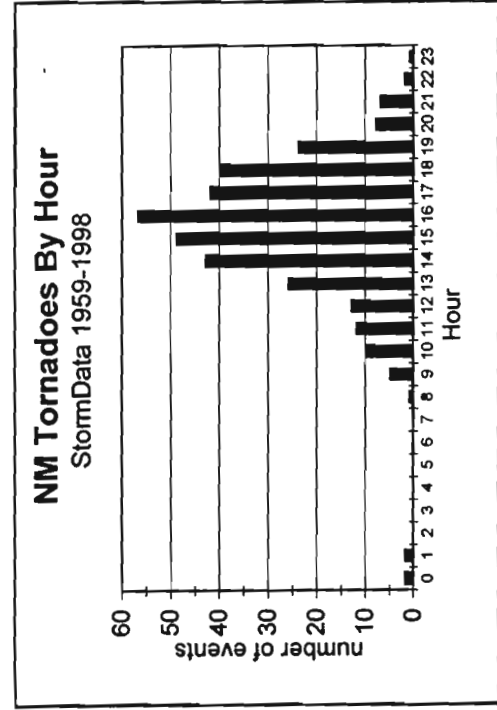
**Figure 7.** Yearly frequency of tornadoes.



**Figure 8.** Tornado frequency by F scale.



**Figure 9.** Monthly frequency of tornadoes.



**Figure 10.** Hourly frequency of tornadoes.

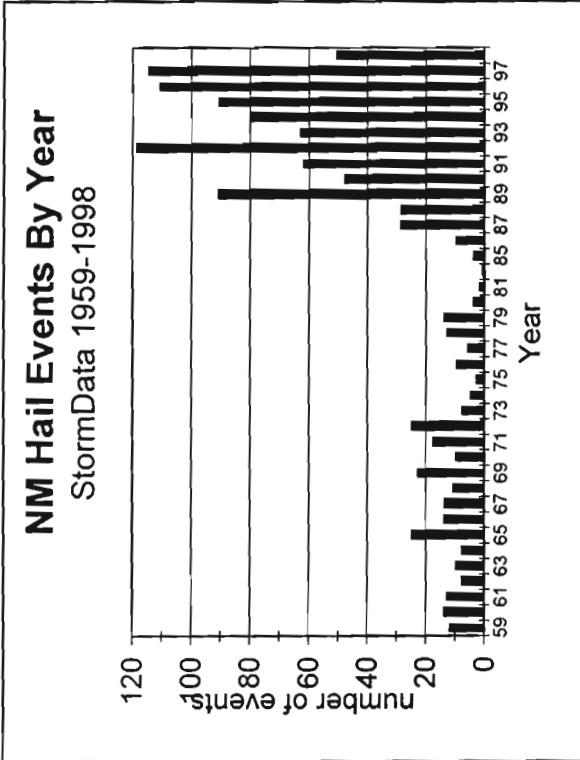


Figure 11. Yearly frequency of significant hail events.

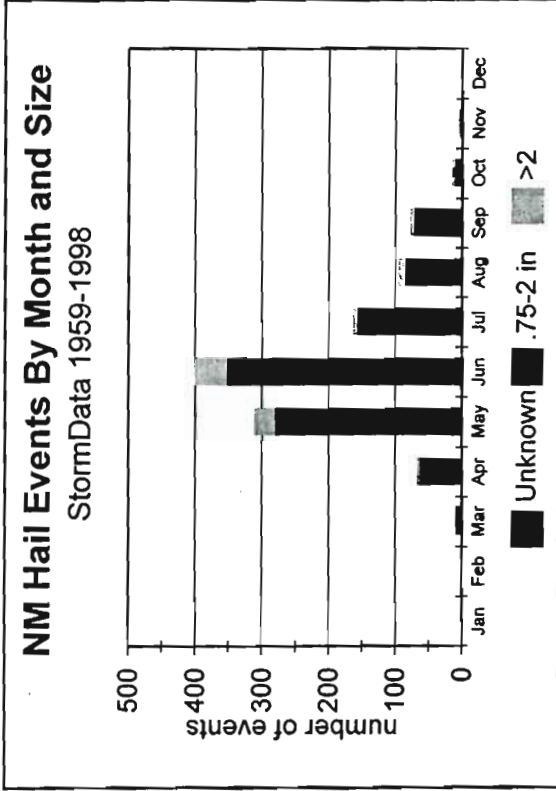


Figure 12. Monthly frequency and very large hail.

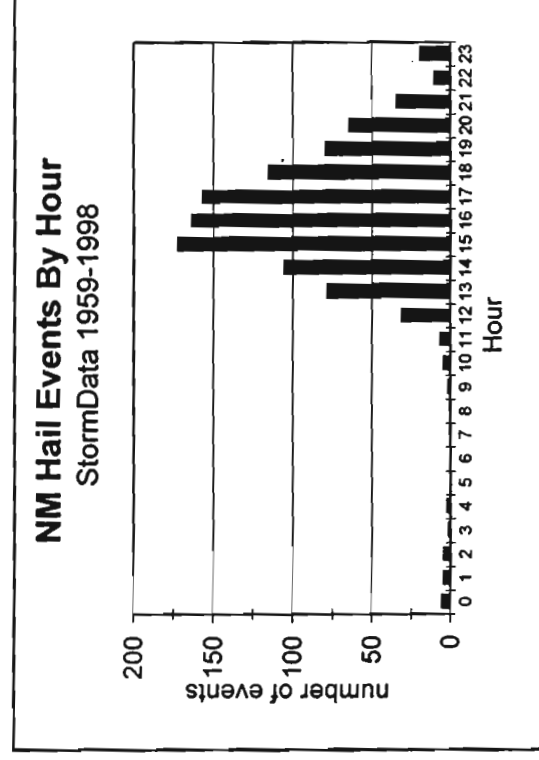


Figure 13. Hourly frequency of hail.

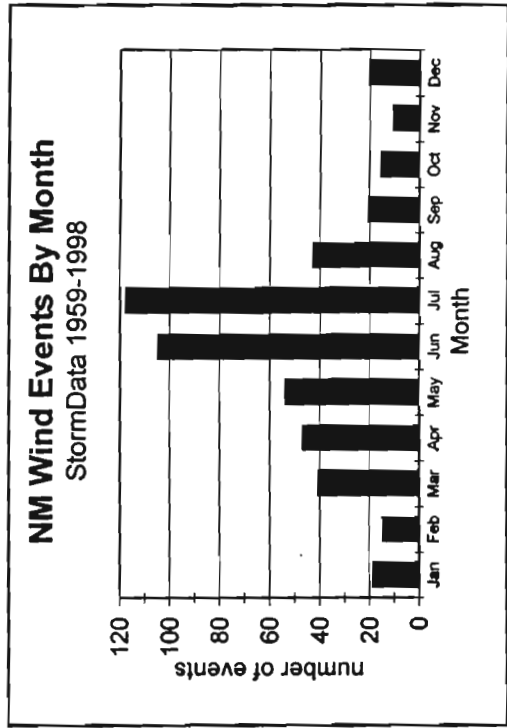


Figure 14. Monthly frequency of all wind events causing injuries or fatalities.

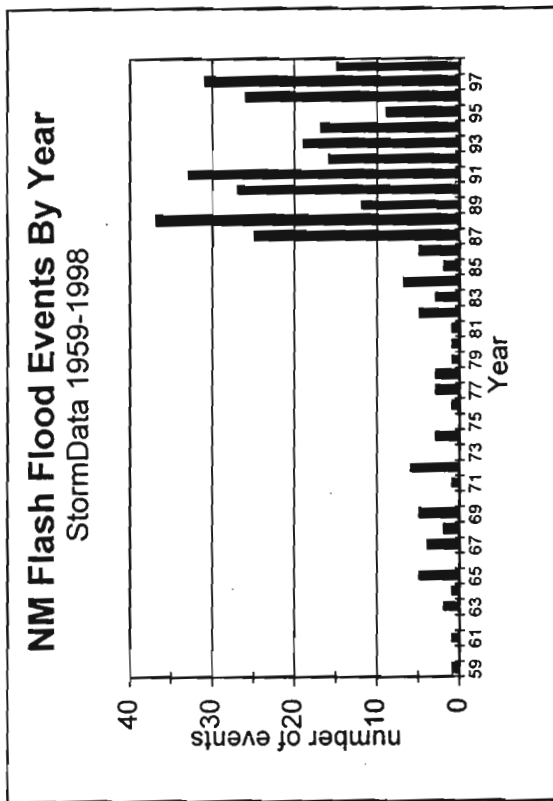


Figure 15. Yearly frequency of flash floods.

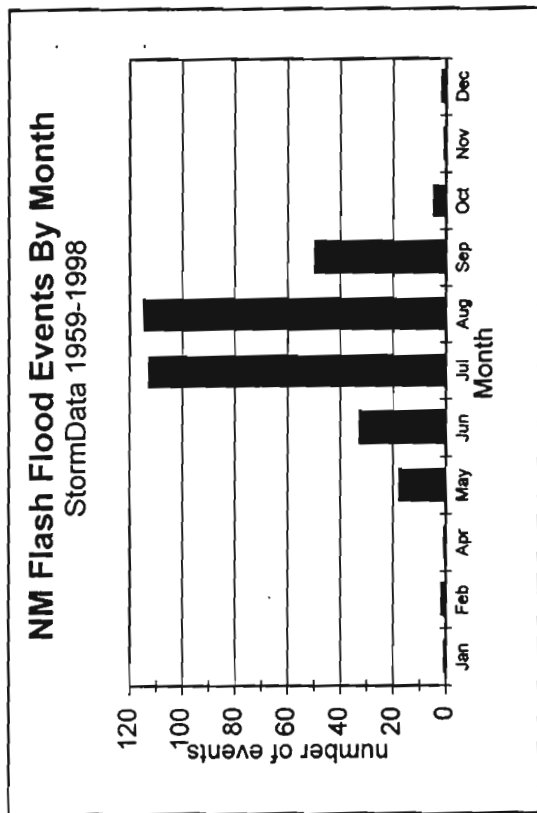


Figure 16. Monthly frequency of flash floods.

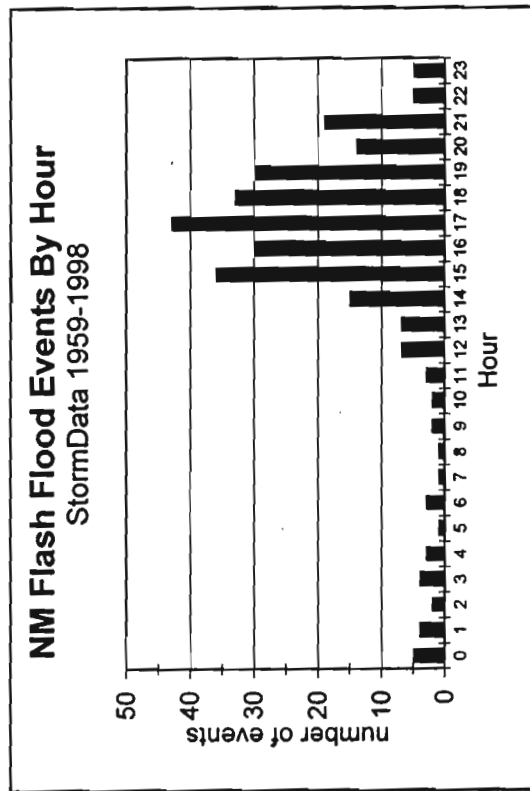


Figure 17. Hourly frequency of flash floods.

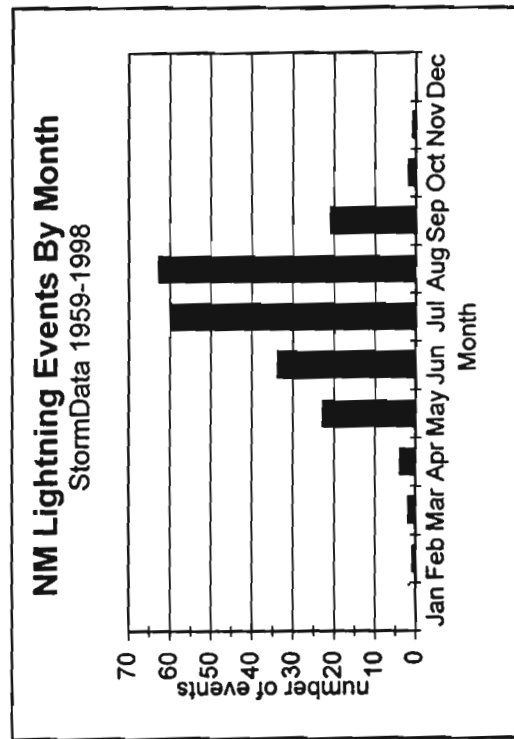
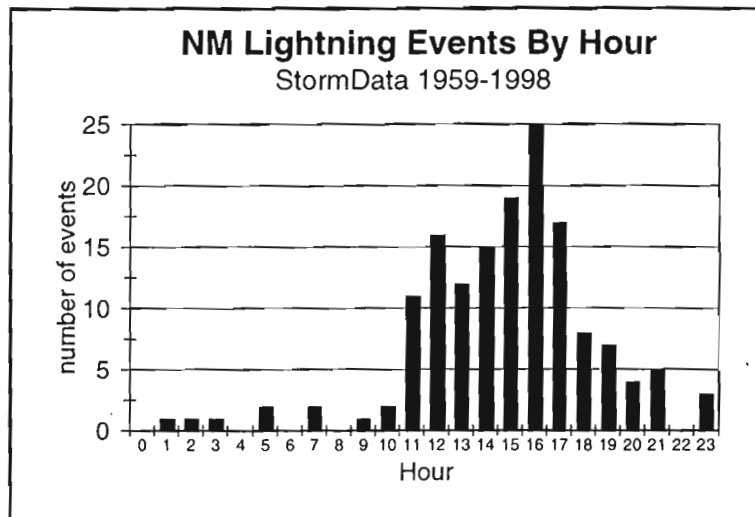


Figure 18. Monthly frequency of significant lightning events.



**Figure 19.** Hourly frequency of significant lightning events.